Update 2004-2008

Lake Simcoe Water Quality Executive Summary

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Ontario

This is an Executive Summary of a technical report that was written by staff from the Water Monitoring and Reporting Section, Environmental Monitoring Branch. A copy of the technical report can be downloaded from the ministry's website: www.ontario.ca/lakesimcoe.

Cover photograph: On Sibbald Point looking east to Duclos point, with the Georgina Island Ferry in the distance.
Credit: Lake Simcoe Fisheries Assessment Unit, Ministry of Natural Resources

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Lake Simcoe Water Quality Executive Summary

Lake Simcoe is the largest lake in southern Ontario, aside from the Great Lakes. Some 400,000 people live in the Lake Simcoe watershed; the population is growing and millions of people are attracted to the lake for swimming, boating, fishing in summer and winter, and vacationing. Lake Simcoe's recreational activities alone bring in some $200 million a year to Ontario's economy.

Lake Simcoe's ecosystem is vitally important. The watershed includes parts of the Oak Ridges Moraine and Ontario's Greenbelt, and some of Ontario's fastest growing communities – there are six drinking water plants that rely on the lake. But for years, Lake Simcoe's ecosystem has been under pressure.

The problems became particularly severe in the 1970s. Lake trout and whitefish populations were in decline. Scientists determined then that the most likely cause was eutrophication – an excess of nutrients entering the lake, mostly phosphorus – which created an oxygen shortage in the deep waters of the lake. Phosphorus comes from agriculture, from sewage, from industries, and from urban areas and lawns.

The Ministry of the Environment began collecting water samples in 1971, and started a monitoring program in 1980 that is still underway in partnership with the Lake Simcoe Region Conservation Authority.

Actions by partnerships in the watershed helped improve Lake Simcoe's water quality, but more was needed. In response to this growing need, the Ontario government announced a far reaching plan including new legislation (passed in 2008) and new measures to help the watershed and its ecosystem. The Lake Simcoe Protection Plan incorporates advice from the *Lake Simcoe Science Advisory Committee*, a panel of the top scientific experts on water quality, and particularly, Lake Simcoe's water quality.

This is a summary of a report on Lake Simcoe's water quality written by Ministry of the Environment scientists that describes the most recent data available for key water quality stressors identified by the Science Committee and their effects on the lake.

Lake Simcoe, Ontario, Canada

What the scientists measured

The scientists looked at changes in Lake Simcoe's water quality. They measured:

- Nutrients – phosphorus, phosphate, nitrogen, etc.
- Algae & plants – weeds and other plants that clog waterways and outflows and also absorb oxygen
- pH levels – alkalinity/acidity
- Dissolved organic and inorganic carbon
- Other ions, such as calcium, manganese, sodium, potassium, chloride, sulphate
- Water clarity
- Water temperatures and dissolved oxygen – how much oxygen is there for the fish and aquatic life?

What we know about Lake Simcoe

Lake Simcoe has a large surface area – 722 square kilometres. The entire watershed is 2,899 square kilometres (more than 10 times the size of the City of Toronto). It receives an average of about 1,000 millimetres of precipitation each year – about three quarters of this is rain.

The area's average air temperature in January is minus 8°C; the July average is 20.5°C. The lake surface usually freezes in winter but not always.

Lake Simcoe has two bays, the narrow and deep Kempenfelt Bay near Barrie and shallow Cook's Bay at its southern end, and a large main basin that is quite shallow on the east side. At its deepest, Lake Simcoe is around 40 metres deep.

The lake drains through an outlet at Atherley Narrows (into Lake Couchiching); it takes about 11 years for Lake Simcoe to "flush" (that is, for all the water to be replaced). The water in Lake Simcoe is "hard" or alkaline, due to the limestone bedrock underlying its catchment. The prevailing soils in and around the lake are clays and organic soils.

The Lake Simcoe Science Advisory Committee

The Lake Simcoe Science Advisory Committee was appointed as part of the Ontario government's plan for protecting the lake and its watershed. The committee had 11 members, all experts in the water quality and ecology of lakes and their basins, and the impacts of surrounding urban and agricultural uses.

The committee's advice helped ensure that the Lake Simcoe protection strategy is based on the best available science. The scientists considered the present state of the lake and its watershed, looked at pressures on the system, identified what parts of the ecosystem needed protection and advised on how to manage all this.

The committee's co-chairs were Dr. Peter Dillon and Dr. Jennifer Winter, both highly respected scientists in their fields, and very knowledgeable about Lake Simcoe.

What we're learning about Lake Simcoe

Stratification

The deeper parts of Lake Simcoe undergo *summer stratification* – in the spring and early summer, a warm surface layer is formed that does not mix with the cold bottom layer below. When the surface cools in the fall, the lake starts to mix again. The shallowest areas of the lake (about 3 metres deep) remain un-stratified (mixed) all year.

Stratification occurs 20 days earlier in the spring than it did in 1980 and ends in the fall 15 days later compared to thirty years ago. There is some evidence that climate change is a factor; longer stratification periods may result from shorter periods of ice cover on the lake or more rapid warming in the spring. Whatever the cause, the changes in the patterns of stratification can make a difference, affecting the phytoplankton and oxygen levels, and therefore the fish and ultimately the entire ecosystem.

Ice opening up on Lake Simcoe. Credit: Lake Simcoe Fisheries Assessment Unit

Climate Change

Ontario is working on a comprehensive set of programs to reduce the province's greenhouse gas emissions that contribute to climate change. But the effects of climate change are already being observed, requiring adaptive measures to minimize impacts.

Dissolved Oxygen

When the lake stratifies, the cool bottom waters contain a maximum concentration of dissolved oxygen. As the summer progresses, this oxygen is slowly consumed by organic matter (primarily algae) that decomposes. Freshly oxygenated water doesn't reach the deeper parts of the lake until the waters mix again in the fall.

Throughout the 1980s, dissolved oxygen concentrations measured at the lake bottom reached 2 mg/L or lower in most years. But to sustain Lake Simcoe's coldwater fish, the concentration should be 7 mg/L. The Lake Simcoe Protection Plan has set this as the target.

Rocks in the water off Sibbald Point. Credit: Lake Simcoe Fisheries Assessment Unit

Oxygen concentrations have been getting better during the 1990s and 2000s, although the five year running average has remained below the 7 mg/L minimum target. In contrast, there has been no significant change in oxygen depletion rates over the past 30 years. With stratification occurring earlier in the spring and lasting longer into the fall, more oxygen should be consumed by the end of summer if the same depletion rate exists. Because dissolved oxygen concentrations are going up, it suggests that greater oxygen saturation exists when waters mix in the spring.

Phosphorus and other nutrients

Phosphorus is a major water quality concern in Lake Simcoe. While some phosphorus is required to support a healthy aquatic ecosystem, too much phosphorus leads to excessive plant growth. When these plants decay, oxygen that is required by fish and other aquatic species is depleted. Because of oxygen depletion, the continued existence of lake trout or lake whitefish in Lake Simcoe is almost entirely due to a hatchery stocking program.

Phosphorus levels have been going down. The most substantial decreases in phosphorus occurred in the 1980s and early 90s – levels have been relatively constant or even increased during the past decade. But while a decrease in phosphorus is improving oxygen conditions in the lake, the improvements are not yet sufficient for the fish to sustain themselves naturally.

Holland Marsh looking north towards Bradford. Credit: Nick Wilson

Phosphate decreased after 1989, when the Canadian Environmental Protection Act set limits on phosphate concentration in laundry detergent. New regulations being proposed to take effect in 2010 would limit phosphates even more, and include dishwasher detergent too.

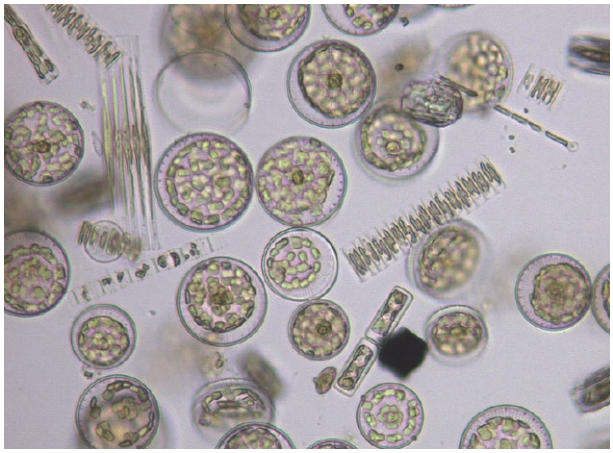
Total ammonia is lower in concentration now in the lake than it was in 1980. This is positive, because in most cases, ammonia is toxic. When it does enter the lake, it comes from discharge from Lake Simcoe's 14 sewage treatment plants and from agriculture. The situation improved substantially after the rules for waste treatment plants were tightened in 1989.

The concentration of phosphorus entering Lake Simcoe from tributaries varies. Loading in the main part of the lake per unit volume of lake water was relatively light compared with Cook's Bay at the south end, which has the highest concentrations of phosphorus in the lake water.

Algae

Chlorophyll *a* concentrations are used as a measure of algal abundance. Concentrations of chlorophyll *a* generally decreased through the 1980s and 1990s, but have since levelled off, and, in recent years, have increased slightly at several stations across the lake.

Biovolume is another way to measure algal abundance in the lake. Similar to chlorophyll a trends, algal biovolume declined through the 1980s and were at the lowest levels during the late 1990s but have since increased. The greatest biovolumes were found in Cook's Bay, where they were two to three times greater than those in the main basin.



Diatoms collected from the intake pipe of the Georgina water treatment plant

Water Clarity

Water clarity is affected by algae, suspended sediment and coloured organic matter. Since 1980, water clarity across the lake has improved by 30 to 50 percent. The most substantial increases in water clarity occurred since 1996, coinciding with the widespread establishment of zebra mussels following their introduction in the lake in 1994. Because zebra mussels are highly effective filter feeders clearing large volumes of water per day, their colonization of a lake often produces dramatic increases in water clarity. Clearer water can cause an increase in aquatic plants that clog the water making swimming and boating less fun.

What about other issues?

Phosphorus and dissolved oxygen are the two main priorities in the restoration and protection of Lake Simcoe. But they are not the only concerns being addressed – scientists and policy makers are also looking closely at pathogens, pollutants, invasive species and other issues.

Chloride

Although Lake Simcoe is a large lake situated in a basin with a relatively small proportion of urban land use, the use of road salt in the basin over the years has altered the lake's water chemistry.

Within the lake, chloride concentrations, mostly from road salt, have increased. Although the levels are still well below guidelines, there is reason to be concerned because levels are continuing to increase and chloride may cause detrimental ecological effects. Salt will continue to be monitored in the lake, and improved road salting practices and actions to reduce storm-water runoff should reduce inputs in the future.

Metals and Organic Contaminants

A sediment survey was conducted in 2008 in Lake Simcoe in partnership with Environment Canada to measure current and historic levels of metals and organic contaminants. The highest concentrations of metals were found in Kempenfelt Bay sediments, from urban and industrial sources. These concentrations decreased along a west to east gradient. Concentrations of metals such as chromium have decreased from peak levels, but they are still much higher than sediment concentrations before 1800. Concentrations of metals are typically low in the lake water.

These contaminants are being reduced thanks to improved wastewater treatment and changes in industrial activity. However, metals typically found in uncontrolled urban storm water run-off (for example, zinc) remain at elevated concentrations.

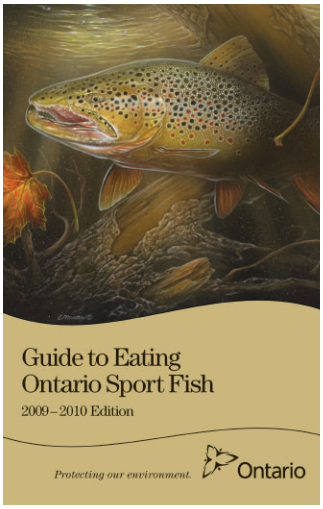
Box Corer after deployment in Cook's Bay while sediment sampling. Credit: Benoit Lalonde, Environment Canada

The scientific team also looked at a number of organic chemicals in its 2008 sediment survey. These included polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). PCBs were used in electrical transformers and building sealants but have been banned for decades and are being replaced as they are found and buildings are renovated. PAHs are a by-product of the burning of fuels and are also present in asphalt and roofing tar. PCBs and PAHs have declined from peak concentrations in 1970 and the late 1950s respectively, but they are still above pre-industrial levels.

Current concentrations of PCBs and PAHs are greatest in Kempenfelt Bay, reflecting past emissions and recent residual inputs from the Barrie area.

Recently, more focus has been put on other persistent organic chemicals that have been widely used as flame retardants and surface active agents.

Polybrominated diphenylethers (PBDEs) have been used in furniture foam, fabrics and plastics to prevent the spread of fire. The perfluorinated chemicals, such as perfluorooctane sulfonate (PFOS) and acid (PFOA) have been used to provide stain resistance to carpets and fabrics, and in the production of polymers. Current sediment concentrations of these chemicals were more evenly distributed across Lake Simcoe than the PCBs and PAHs. This may indicate that inputs from sources outside of the watershed, resulting from their widespread use in the populated regions of Southern Ontario, are just as important as direct inputs from urban centres within the watershed. PBDE concentrations have increased over the past two decades; however, this is expected to change in coming years as some PBDEs have been withdrawn from the market and others are coming under regulation.



Can we eat Lake Simcoe fish?

Based on Ontario's sport fish contaminant monitoring data used in the *Guide to Eating Ontario Sport Fish*, levels of contaminants such as PCBs, DDT, and dioxins and furans in sport fish (e.g., lake trout, walleye and whitefish) have decreased or remained stable over the last 10 to 15 years. Levels of these contaminants in Lake Simcoe fish are generally equal to

or lower than levels found in Great Lakes fish. However, mercury levels in whitefish from Lake Simcoe have actually increased slightly, possibly due to changes in lake food web structure. The *Guide to Eating Ontario Sport Fish* shows which fish are safe and at what quantities.

Pathogens

Pathogens are a key water quality concern because they directly threaten human health.

On Franklin Beach looking west

Beaches are routinely monitored for *Escherichia coli (E. coli)* – an indicator of fecal pollution – and presence of pathogens such as bacteria, protozoa and viruses. Sources of pathogens include sewage spills, leaking septic systems, discharge from boats, animal waste from urban and agricultural runoff, and birds and other animals present at the beach. Beach sand can also harbour bacteria, including *E. coli*, and the problem can become worse from rainfall and offshore winds.

Lake Simcoe's beaches are sampled from June through to August by the Durham, Simcoe and York Health Units. Beaches are posted with swimming advisories when geometric mean concentrations of *E. coli* exceed an acceptable standard or when other adverse conditions occur. Beaches remain posted until laboratory results show that bacteria levels are safe.

From 2006 to 2008, most beaches had at least one posting or closure; only three beaches at the north end of the lake remained posting-free. Advisories were rarely posted in Kempenfelt Bay, although all six beaches were pre-emptively closed for one day in 2006 after a sewage spill occurred.

Beaches along the south and east shore of the main basin were closed most frequently and for the longest duration. The higher number of postings due to poor water quality along the south and east shores may be due to a greater tendency for onshore wind direction, more sources of bacteria or a combination of both.

Invasive Species

Zebra mussels invaded Lake Simcoe in 1994. We don't know everything about their effect yet, but it is believed that due to their rapid, widespread establishment and high filter feeding capacity, they have likely impacted water quality in Lake Simcoe in numerous ways.

Zebra mussels

These include increased water clarity, reduced algae and lower alkalinity and calcium concentrations. Zebra mussels are also thought to affect phosphorus cycling in lakes by converting particulate-bound phosphorus to more reactive forms and by increasing concentrations near the shore. Research on zebra mussels continues.

Eurasian watermilfoil invaded the lake in 1985 and is currently one of the most abundant aquatic plants there. It is among the most troublesome invasive species in freshwater lakes across North America. It interferes with swimming and fishing, reduces dissolved oxygen and increases the population of mosquitoes. Watermilfoil can grow into dense stands and can replace native species.

Other species that have invaded Lake Simcoe include several species of fish (common carp, rainbow smelt, bluegill, black crappie, round goby), zooplankton (spiny waterflea), crayfish (rusty crayfish) and another macrophyte (curly pondweed). To protect the lake ecosystem from invasive species, the Lake Simcoe Protection Plan recommends taking steps to prevent further invasions.

Drinking Water

Water from Lake Simcoe's water treatment plants meets Ontario Drinking Water Quality Standards.

There are six municipal residential drinking water treatment plants along Lake Simcoe's shores that serve more than 55,000 residents.

Drinking water quality is tested regularly at each of these plants. In addition, the municipal owners of three of Lake Simcoe water treatment plants also participate in the Drinking Water Surveillance Program, a voluntary monitoring program that has been operated by the Ministry of the Environment in co-operation with municipalities since 1986 (http://ontario.ca/dwsp). Owners of Alcona, Beaverton and Keswick plants have participated since 2000 or earlier; however, Beaverton left this program in 2007 while Georgina joined in 2009.

Water samples are collected approximately four times per year and are analyzed for over 250 water quality parameters, whether health-related or aesthetic objectives or operational guidelines. Scientists looked at three parameters that did not meet the health-related Ontario Drinking Water Quality Standards at monitored water treatment plants elsewhere in the province, as indicators of drinking water quality for this report.

One of these, fluoride, is a chemical substance that may be present in source water as a result of the erosion of natural deposits or discharge from fertilizer and aluminum factories. But sometimes it is added to water during the treatment process to promote strong teeth.

Of the three water treatment plants, only Keswick's adds fluoride and, for this reason, fluoride levels were higher there than in the other two systems. All results, including Keswick's, met the Ontario Drinking Water Quality Standards.

Nitrate is present in source water generally as a result of runoff from fertilizer use, leaching from septic tanks, sewage and erosion from natural deposits. Of the 81 treated drinking water samples analyzed, all nitrate results were well within Ontario Drinking Water Quality Standards.

Although seldom used industrially today, N-nitrosodimethylamine (NDMA) was once used as an antioxidant in lubricants and a solvent in the fibre and plastic industries. It is an impurity that is produced during the manufacture of rocket fuels, a by-product of the manufacture of certain pesticides, and it has been found in cosmetics, detergents and food such as cured meats, smoked fish, tobacco and alcohol.

NDMA was only detected in 26 of the 54 treated drinking water results that were analyzed and all results met the Ontario Drinking Water Quality Standards.

Under the 2006 Clean Water Act, potential threats to Lake Simcoe as a source of drinking water are being assessed by the Lake Simcoe Regional Conservation Authority in support of the local Source Protection Committee, which will produce an assessment report. This assessment will lead to a more comprehensive source protection plan that will prevent future impacts and address identified issues.

What's next?

Lake Simcoe is getting cleaner, but more work needs to be done. The lake has experienced some improvements in water quality over the past three decades, but continued efforts towards lake restoration are required.

North Holland Canal in early autumn. Credit: Jim Eddie

The duration of stratification in Lake Simcoe has lengthened over the past three decades at the deepest part of the lake, starting 20 days earlier in the spring and ending 15 days later in the fall.

Phosphorus concentrations at some of the lake stations decreased in the 1980s but there has been little decline in recent years. Phytoplankton biovolumes have also decreased slightly or remained the same over this time, and problem types such as blue-green algae are less abundant.

Water clarity has improved substantially. This is due partly to reduced phosphorus concentrations and corresponding decreases in algae abundance, and the presence of zebra mussels.

Chloride concentrations (from road salt and other sources) are increasing in the lake, while metals and organic contaminants in lake sediments have generally decreased, although they are currently still above pre-industrial levels.

These stressors and others (e.g., invasive species and pathogens) that impact lake ecology and may impede lake restoration efforts will continue to be monitored.

Lastly, Lake Simcoe provides a high quality source of drinking water for six communities.

To support the initiatives in the Lake Simcoe Protection Plan, Lake Simcoe research and monitoring is being enhanced. Two historical lake sampling stations (which were sampled until 1999) are being restored for a total of 10 lake sampling locations, and analysis of all monitored parameters will be continued. Research projects are underway to improve our understanding of the stressors on the lake and their effects on the ecosystem. The results of the research and monitoring will guide the actions and targets set out in the Lake Simcoe Protection Plan and help Ontarians measure progress.

Get Involved

PROTECTING LAKE SIMCOE IS A PARTNERSHIP AMONG ALL OF US.

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